Wildlife & Ecosystem Services:
Science Objectives

Objective #1. To **understand** how spatial and temporal dynamics in environmental and ecological conditions within the ABoVE Study Domain influence:

(a) movement, habitat selection and population viability of a suite of highly mobile terrestrial animal species, and;

(b) accessibility of natural resources to local subsistence communities.

Objective #2. To **provide local stakeholders** - including natural resource agencies, wildlife managers, First Nations, Alaskan natives, and other stakeholders - **with knowledge, products, and tools** that will aid them in making informed management and adaptation decisions.

Boulder, CO January 2017

Highest priority:

Identify data gaps & solutions for studying wildlife – snow interactions

Integrating snow science and wildlife ecology in Arctic-boreal North America

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Goal: To demonstrate the need for temporally and spatially dynamic snow products to help understand how changing snowscapes impact wildlife in ABRs.

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I. INTRODUCTION

- snow covered 9-10 months/year
  - "Snow has it's fingers in everything" – *Matthew Sturm*
- snowscapes have been changing in recent decades

✓ consequences on biogeochemistry, hydrology & energy balance
? consequences on wildlife

- one of the last remaining regions of the planet with intact wildlife communities
- yet the snow data available are often unsuitable/not the most critical:
  - spatial & temporal resolutions
  - spatial & temporal extents
  - physical snowpack variables

II. THE IMPORTANCE OF SNOWSCAPES TO WILDLIFE

Timing of egg laying

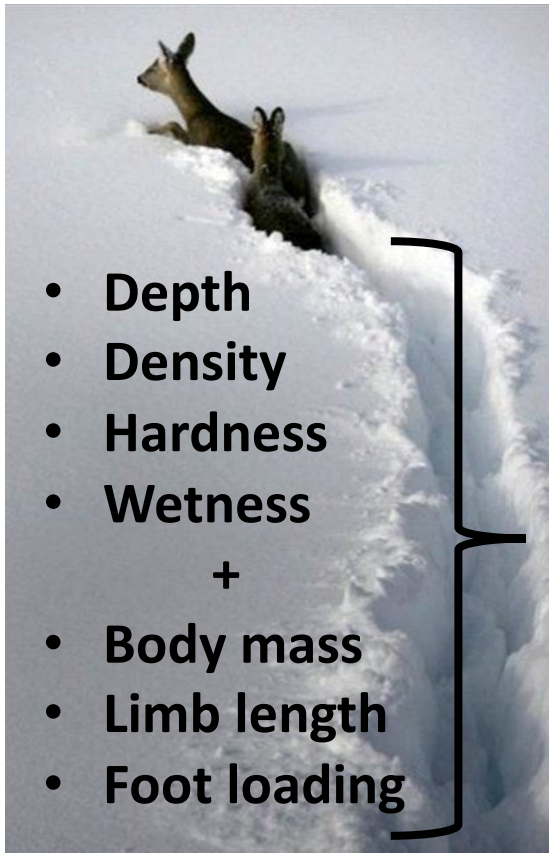
Liebezeit et al. 2014; Green et al. 1977; Meltofte et al. 2007; Smith et al. 2010; Grabowski et al. 2013; Boelman et al. 2017

Predator-prey dynamics

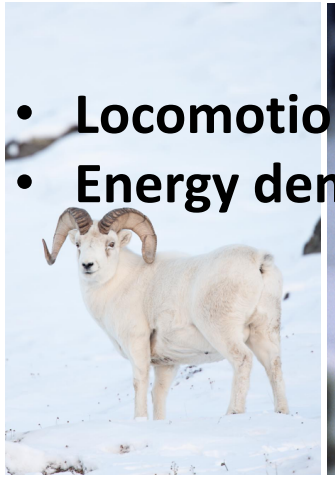
Berteaux et al. 2016; Bilodeau et al. 2013; Duchesne et al. 2011

Zimova et al. 2014; Mills et al. 2013; Henden et al. 2017

II. THE IMPORTANCE OF SNOWSCAPES TO WILDLIFE



Parker et al. 1984; Dailey and Hobbs 1989



Trophic cascade

Fancy and White 1987; Nicholson et al. 2016; Verme 1968; Kelsall and Telfer 1971; Mech et al. 1971; Kelsall and Prescott 1971; Telfer and Kelsall 1984; Pimlott et al. 1969; Mech and Frenzel 1971; Haber 1977; Mech and Karns 1977; Peterson 1977; Eide and Ballard 1982; Peterson and Allen 1974; Haber 1977; Gasawy et al. 1983; Lendrum et al. 2017, Formozov 1946; Nelson and Mech 1986; Hoefs and McTaggart-Cowan 1980; Duquette 1988; Nichels and Bunnell 1999; Johnson et al. 2001; Beumer 2017, Johnson et al. 2001; Putkonen et al. 2009; Rennert et al. 2009; Stien et al. 2012; Hansen et al. 2011; Hansen 2013; Sokolov et al. 2016

II. THE IMPORTANCE OF SNOWSCAPES TO WILDLIFE

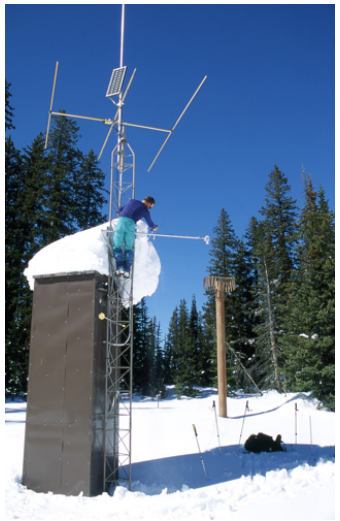
- **Depth**
- **Density**
- **Ice layers**

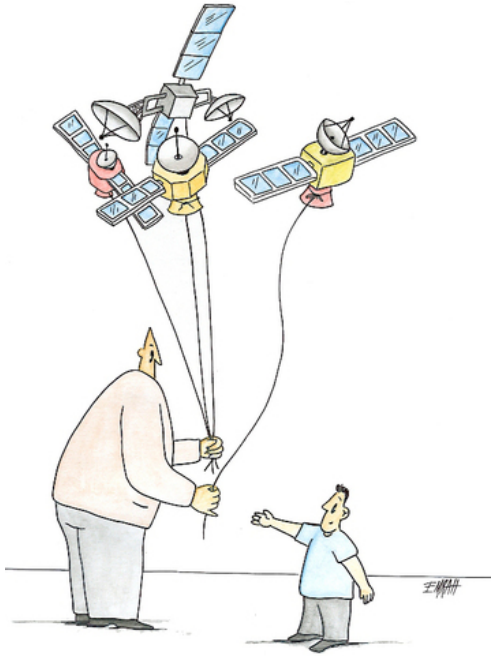
} **Insulative capacity**

Craighead and Craighead 1972; Jonkel 1980; Vroom et al. 1980

A broad suite of snowscape characteristics must be considered!

III. CURRENT GEOSPATIAL SNOWSCAPE PRODUCTS FOR ABRs



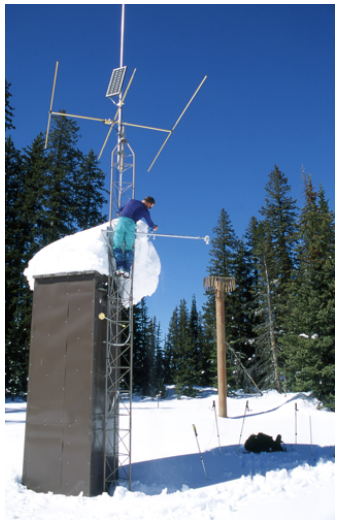


***in-situ* measurements** **remotely sensed observations** **numerical modeling**

model-data assimilation & reanalysis products

All summarized in a comprehensive table – thank you Arjan Meddens!

III. CURRENT GEOSPATIAL SNOWSCAPE PRODUCTS FOR ABRs



***in-situ* measurements**

#2

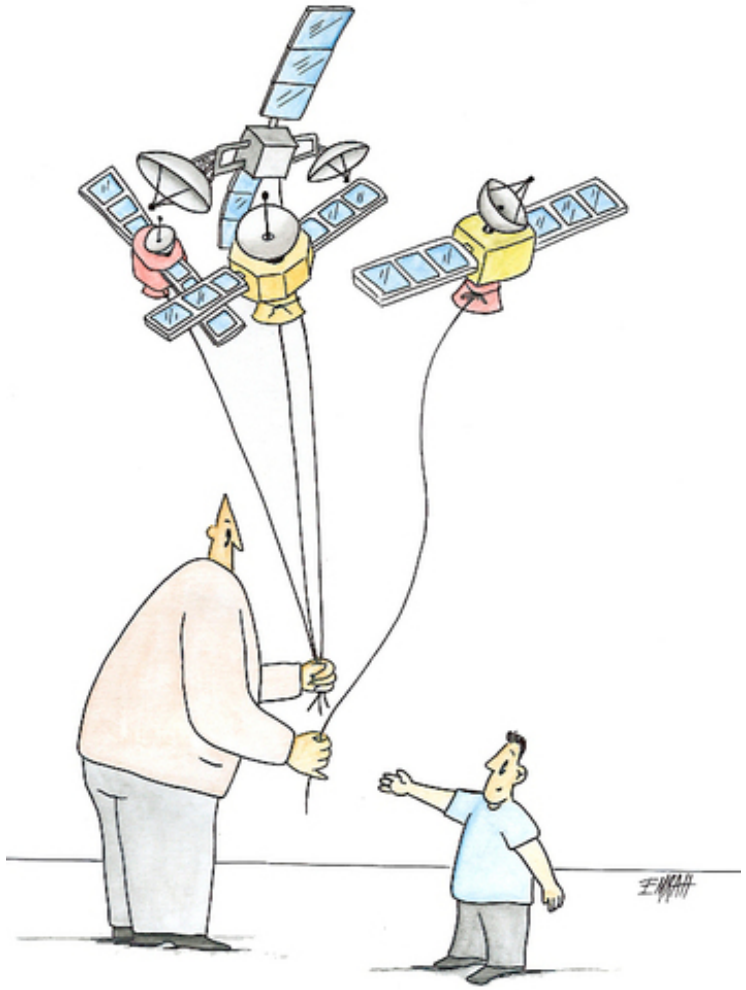
Many sites in the ABR measure:

- SWE
- snow depth
- air temperature

but rarely measure other variables

- ice layers
- hardness

III. CURRENT GEOSPATIAL SNOWSCAPE PRODUCTS FOR ABRs



remotely sensed observations

Daily, vast coverage & spatially continuous snow products:

- albedo
- grain size
- relative ice & water content

But…

#1 most wildlife relevant snowscape properties not available

#2 tradeoff between spatial & temporal resolutions

III. CURRENT GEOSPATIAL SNOWSCAPE PRODUCTS FOR ABRs

numerical modeling

Can be tailored to fit the specific needs of wildlife studies!

- produce a large suite of wildlife-relevant snow variables
- over large spatial and temporal extents
- over a range of spatial and temporal resolutions

But, the majority are not yet up to the task:

#1 most lack adequate spatial resolution and the ability to run at <u>different</u> spatial resolutions (e.g. meters to kilometers)

#2 most do not simulate wildlife relevant snowpack properties because:

- only as good as meteorological forcing inputs
- difficult to develop snow models that are general enough to do a good job everywhere

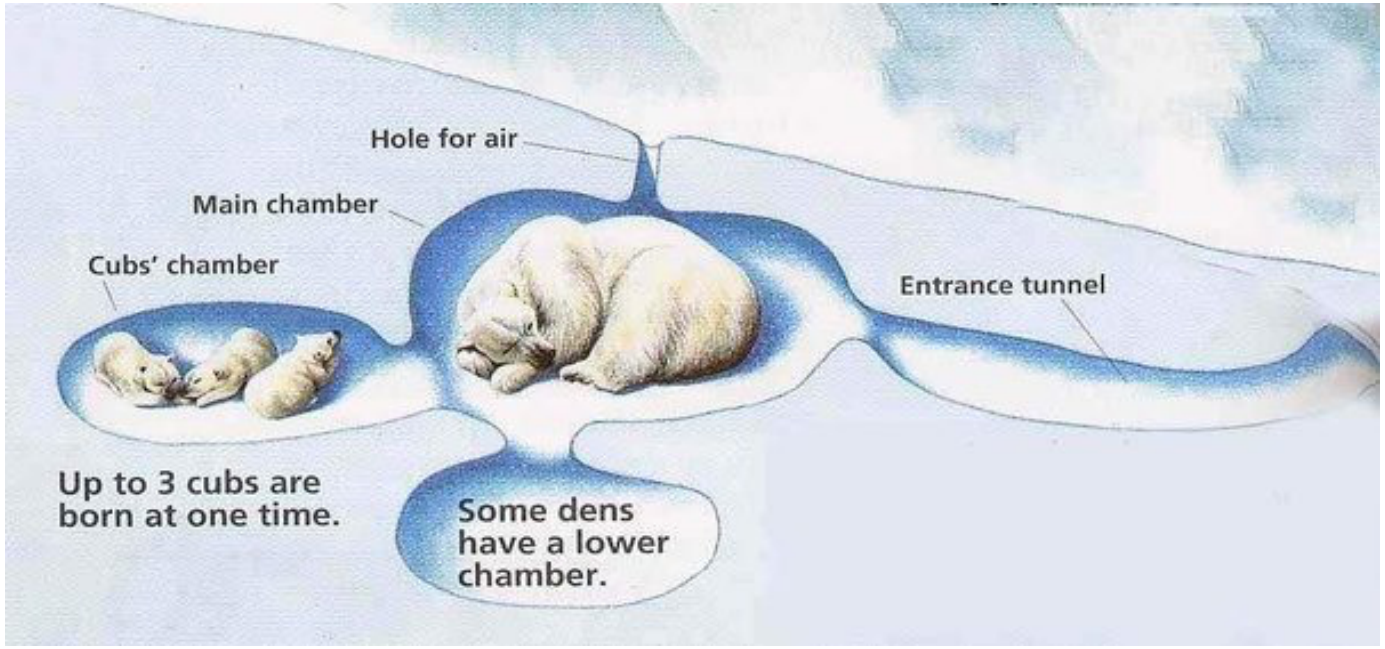
IV. THE IMPORTANCE OF WILDLIFE-RELEVANT SNOWSCAPE CHARACTERISTICS AT APPROPRIATE ANALYSIS SCALES

Case Study 1

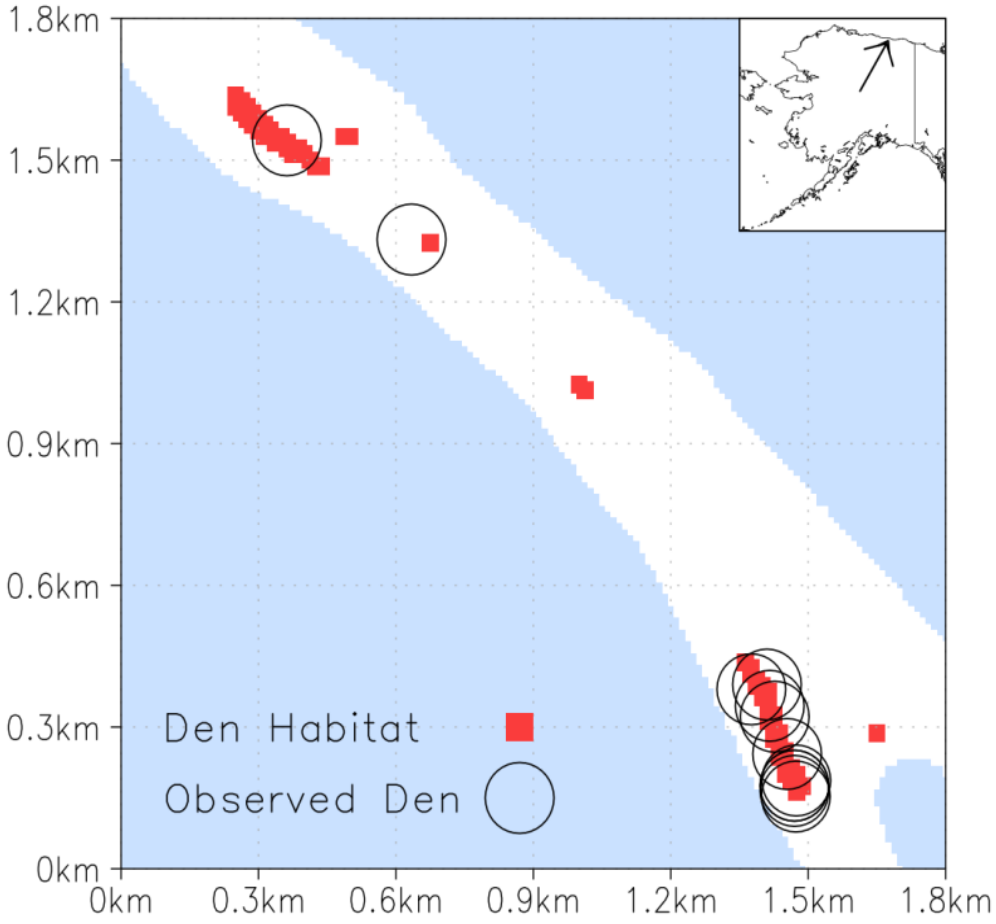
Case Study 2

Case Study 3

Case study 1:



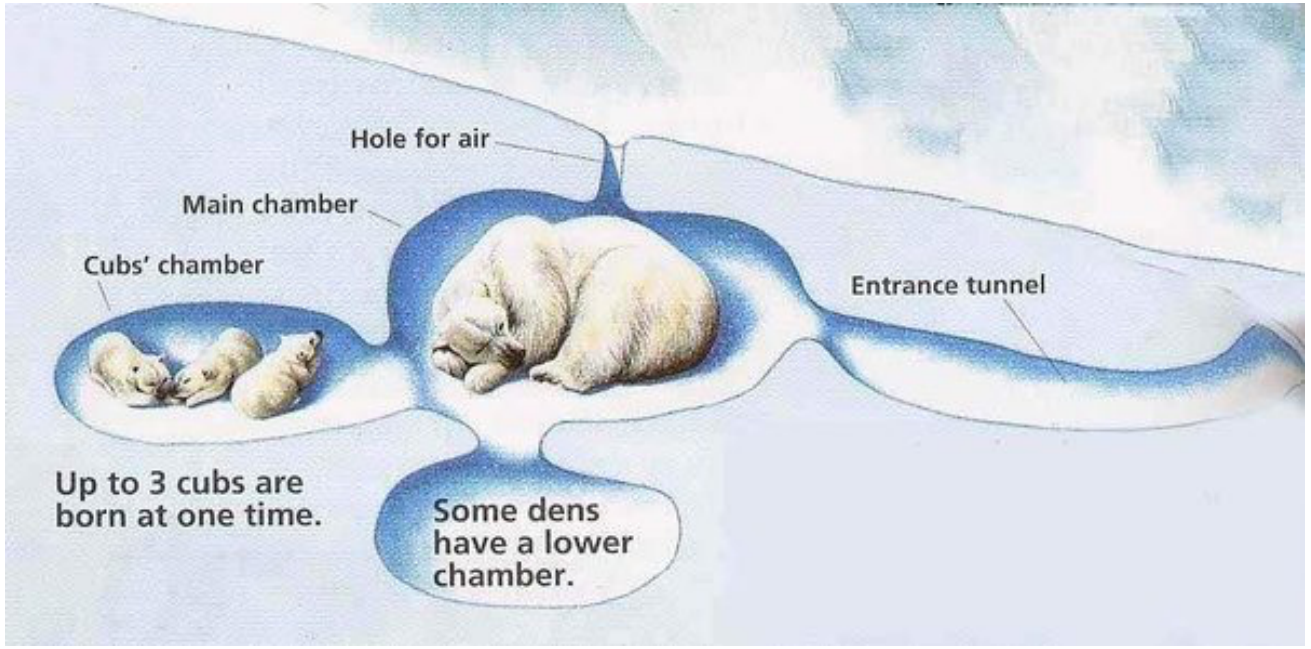
- physically based numerical model (SnowDens-3D) to map polar bear snowdrift den habitat
- simulated the year-specific physical interactions of snow, wind, & topographic dynamics (2.5 m^2 grid)
- created annual maps of snow depth → potential den locations (1995 – 2012)



97% of observed den locations correctly identified by SnowDens-3D

from *Liston et al. 2016*

Case study 1: Mapping polar bear den habitat requires accurate & fine-scale snow depth estimates



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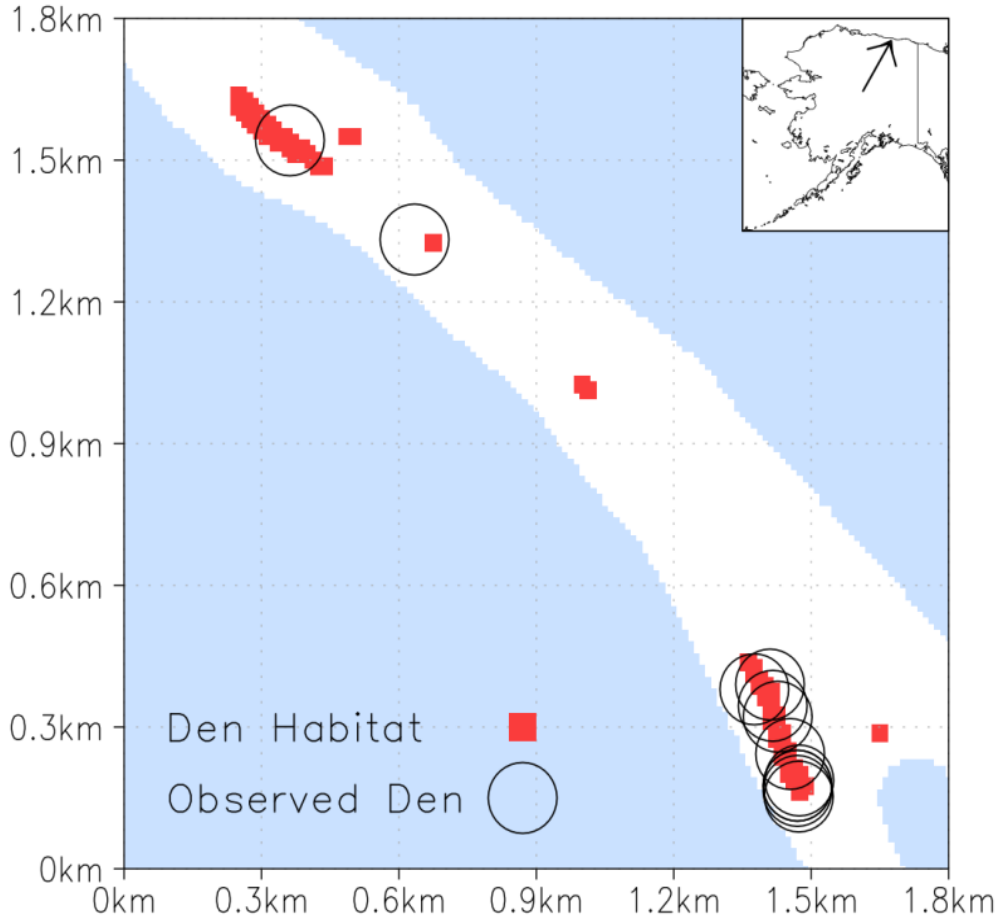

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from *Liston et al. 2016*

Case study 2:

Laura Prugh: Assessing Alpine Ecosystem Vulnerability to Environmental Change Using Dall Sheep as an Iconic Indicator Species

Evaluated the efficacy of:

1. MODIS snow-cover fraction

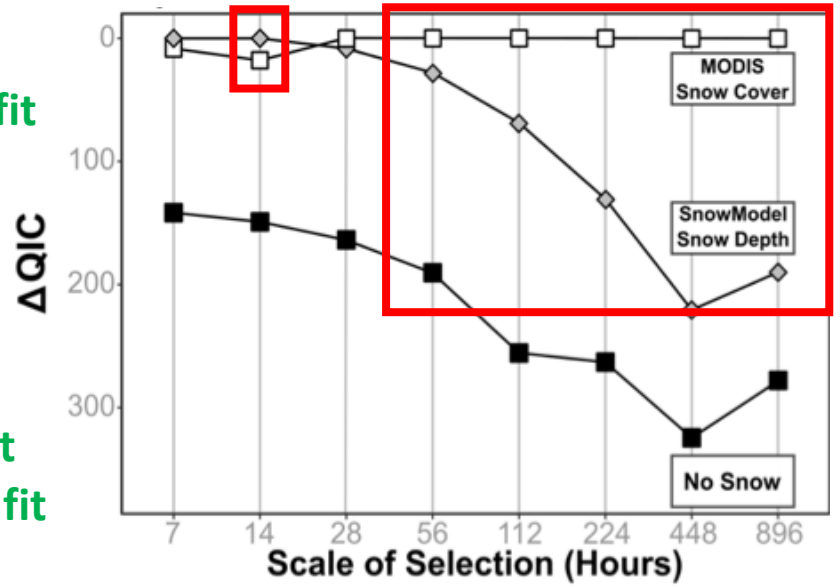
2. SnowModel (Liston and Elder 2006) snow depth & density products

to predict Dall sheep movements at multiple spatial & temporal scales.

from *Mahoney et al. 2017*, in revision

Case study 2:

Best model fit



Worst model fit

- **sheep selected for areas with lower fractional snow cover**

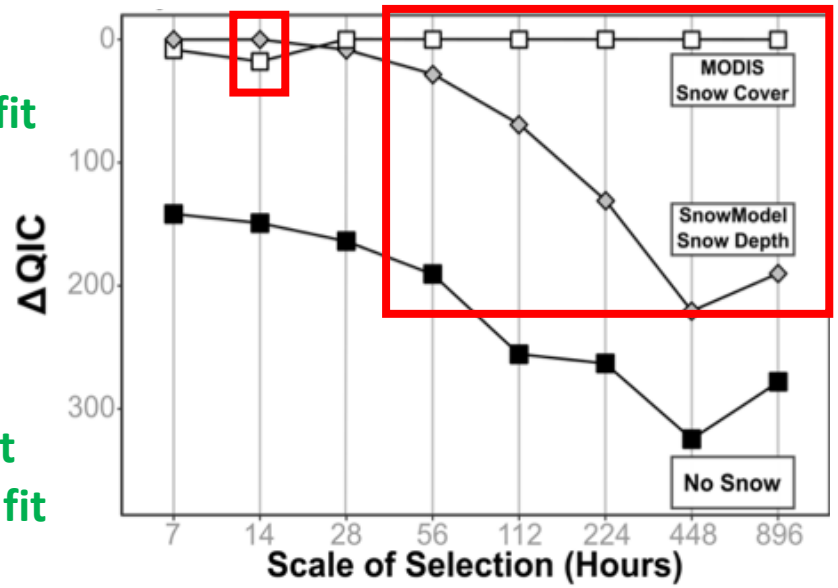
Snow products

No snow

from *Mahoney et al. 2017*, in revision

Case study 2: : Understanding Dall sheep movement behavior requires fine- and coarse-resolution snowscape products, including snow depth

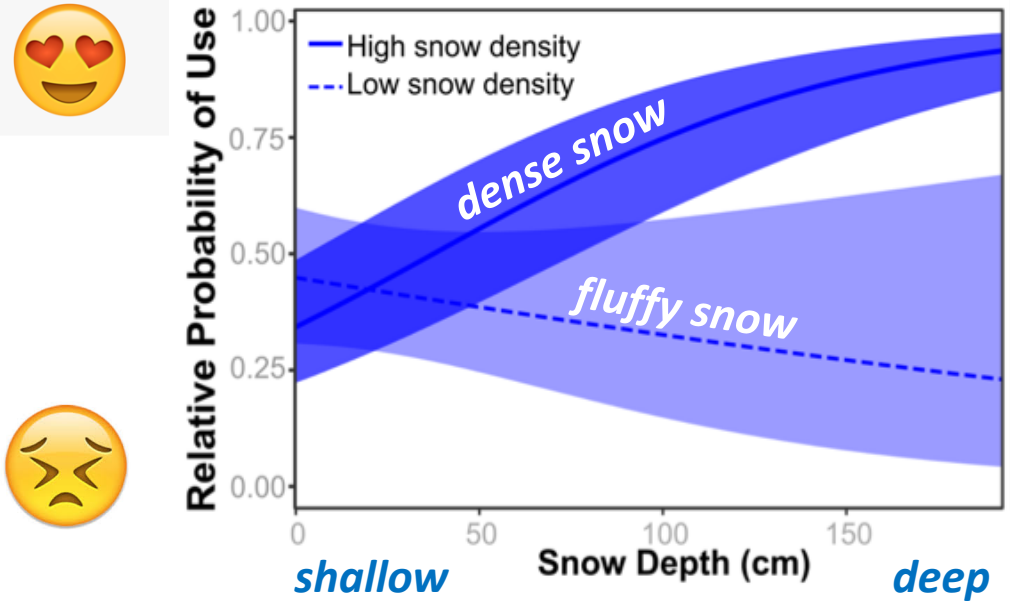
Best model fit



Worst model fit

Snow products

No snow



- **at fine scales, Dall sheep generally selected for:**

(1) low density, shallow snow
- likely to facilitate access to forage and reduce energy expenditure

(2) higher snow density, deep snow
- reduce snow hoof penetration & improve efficiency of movement

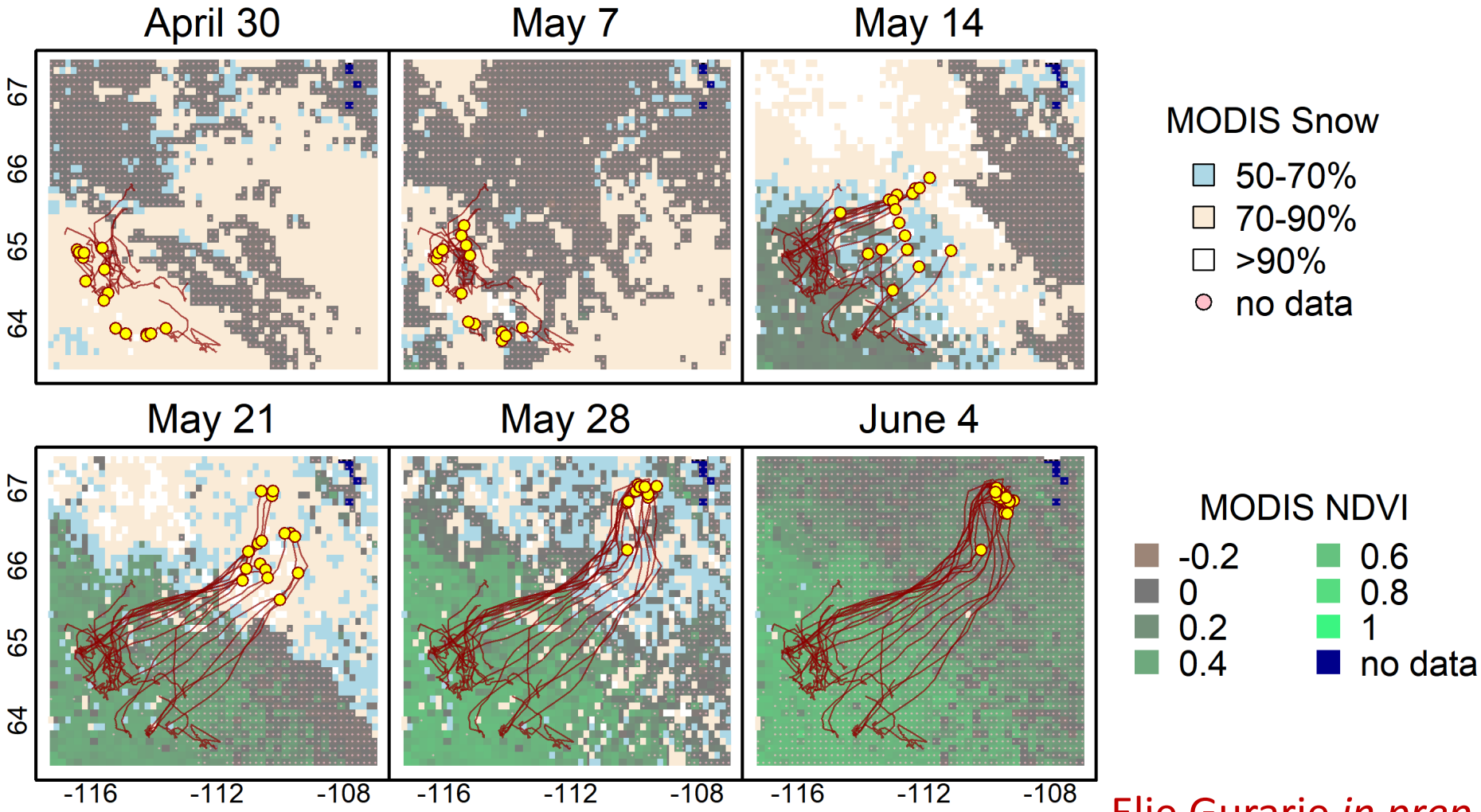
from *Mahoney et al. 2017*, in revision

Case Study 3:

To determine if the timing of caribou spring migration in NW Canada is related to inter-annual variation in snowmelt date as estimated from MODIS snow cover fraction.

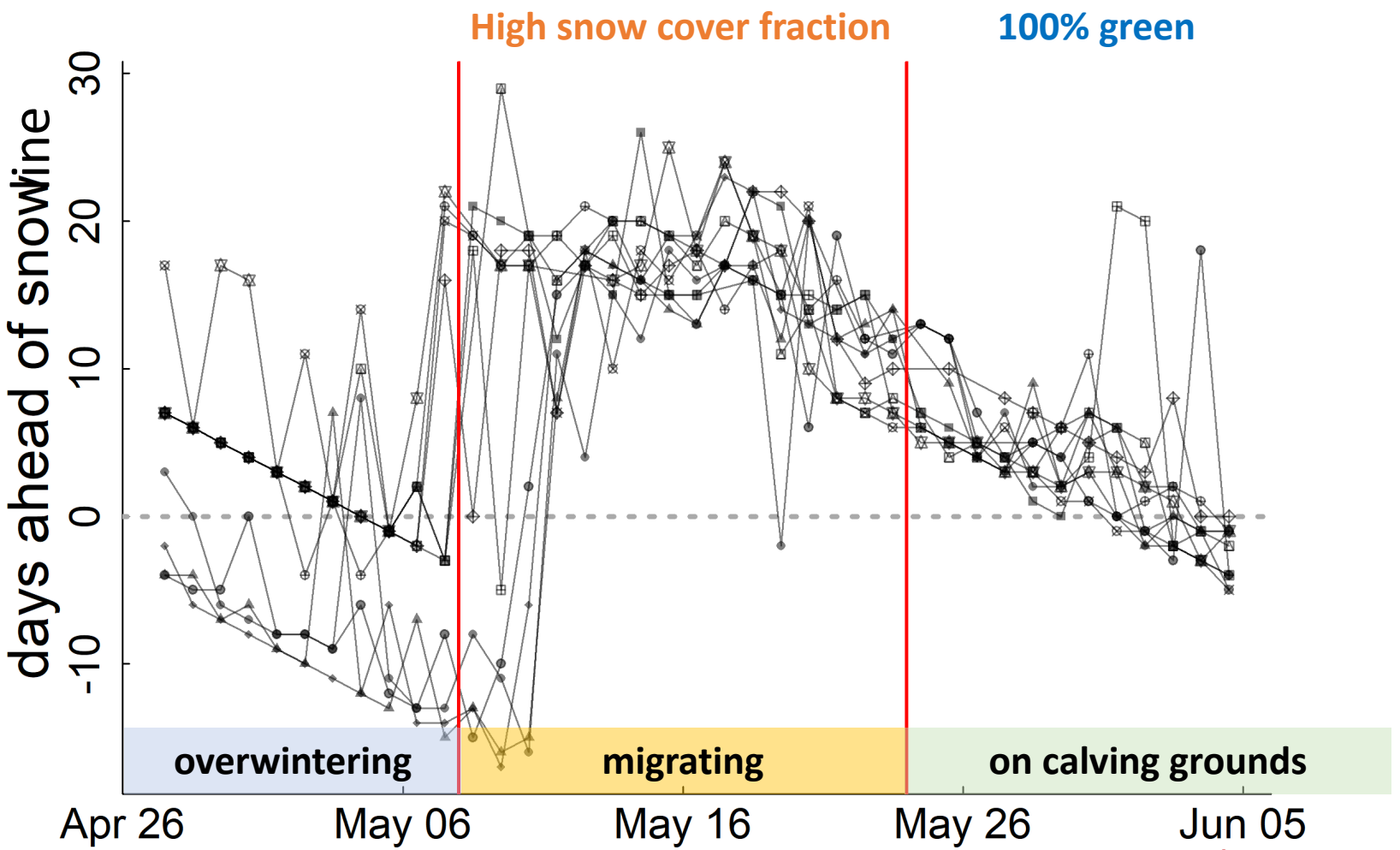
No relationship between snowmelt timing & onset of migration over 14 year period

(supports what Le Corre et al. 2017 in NE Canada)



Elie Gurarie *in prep.*

Case Study 3:

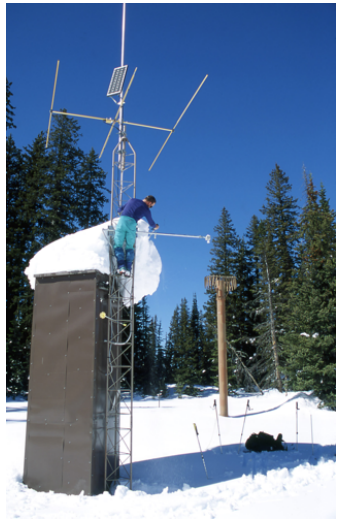


Elie Gurarie *in prep.*

Case Study 3:

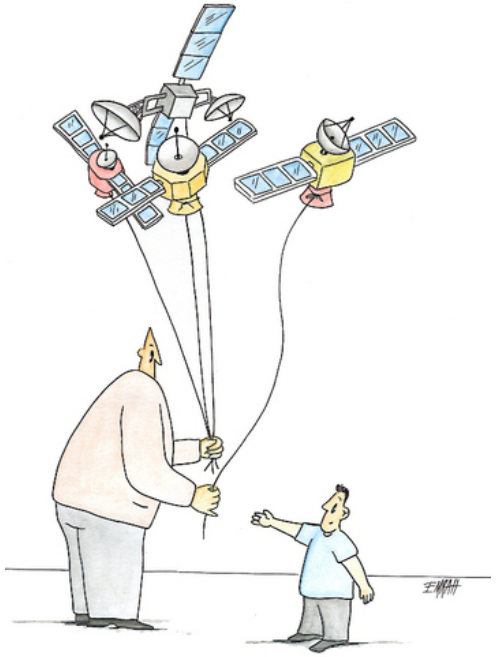
- timing of spring migration *not* linked to timing of snow cover melt
- but animals prefer to migrate over complete snow cover
- Le Corre et al. (2017) suggest they are ‘chasing’ high *quality* snow cover

V. A FUTURE PROSPECTUS FOR IMPROVING WILDLIFE-SPECIFIC SNOWSCAPE PRODUCTS FOR ABRs



***In situ* measurements**

Limitations & Missing data



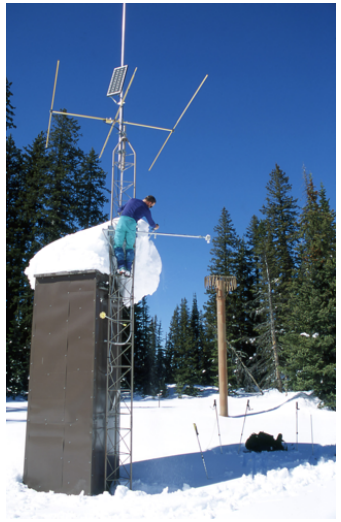
remotely sensed observations

Limitations & Missing data

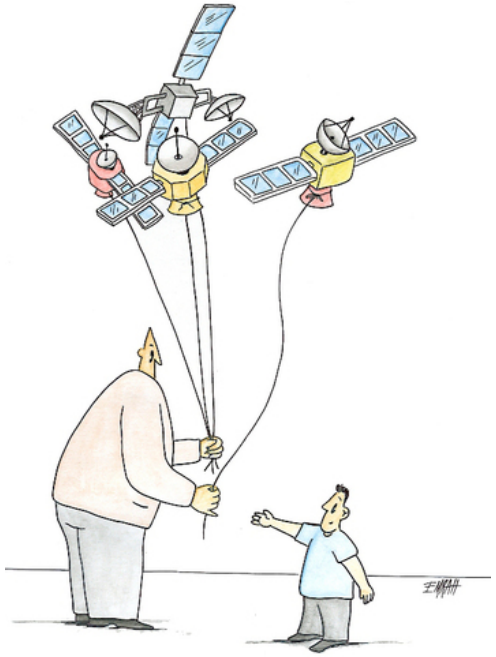
numerical modeling

Glen Liston

V. A FUTURE PROSPECTUS FOR IMPROVING WILDLIFE-SPECIFIC SNOWSCAPE PRODUCTS FOR ABRs



Limitations & Missing data



Limitations & Missing data

***In situ* measurements**

Detailed temporal coverage

remotely sensed observations

Vast spatial coverage

numerical modeling

Large suite of wildlife-relevant variables

Data-model fusion

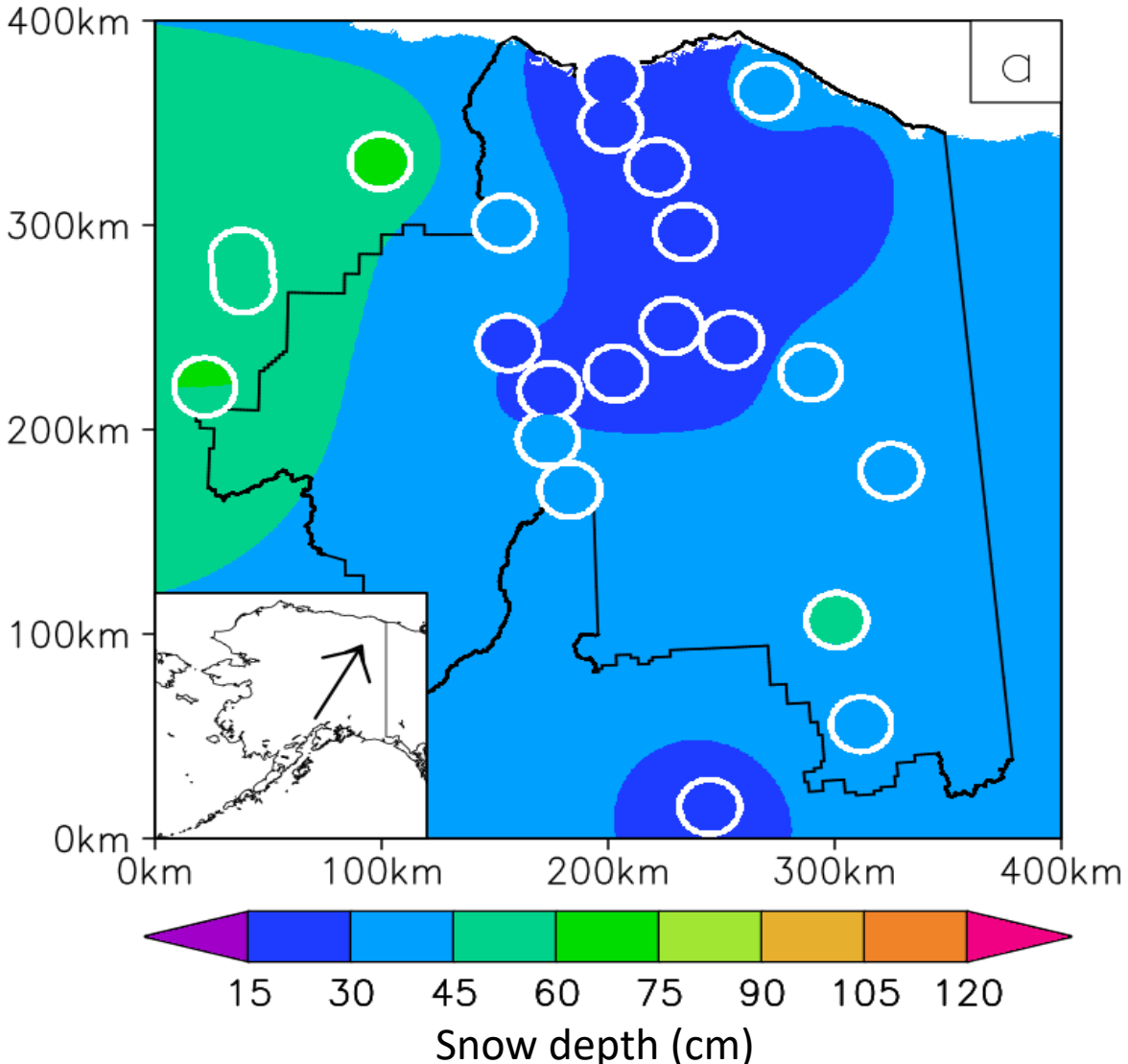
A synergetic extraction and dynamic merging of information obtained from different sources that can 'fill in' for one another.

Glen Liston

Snow Depth: Arctic National Wildlife Refuge (ANWR)

in situ **Observations**

(spatially interpolated)



VI. CONCLUSIONS

- We need fit-for-purpose snow products in ABRs
- We hope that ABoVE will lead the way in improving snow science
- We think Data-model fusion is the the way to go
- But this requires active development & contributions from all 3 constituents

OUR NEXT SYNTHESIS ACTIVITIES ?

- changing seasonality & veg. phenology

  vs.

  wildlife phenology & seasonality in subsistence resource availability

- wildlife – fire interactions

Wildlife & Ecosystem Services Working Group

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